PFAS SAMPLING IN DEER AT AN AFFF SITE, NEW YORK

Visit Parsons at booth #135

Mark Rigby, PhD
Todd Belanger, MSc
Karla Leslie, PhD, PG
Beth Badik
Janelle Bartscherer
Steve Rembish, PhD
Christoper Gallo

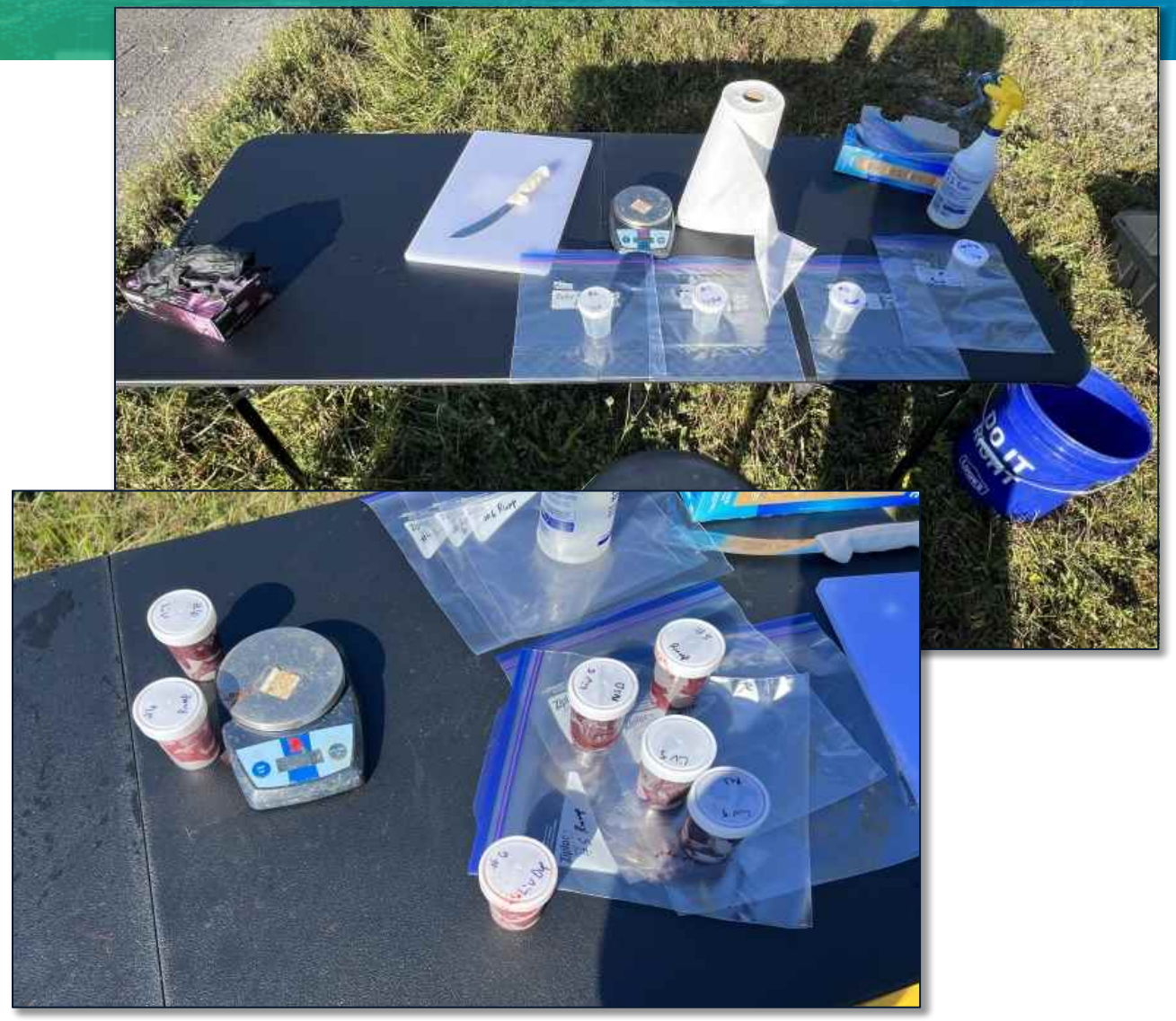
6 June 2024

SITE: HISTORY AND AFFF SOURCES

- **Former base in New York: used 1943 – 2000**
- **Potential PFAS Sources**
  - 3 fire stations
  - 2 fire training areas
  - airfield
- **Hunting:**
  - Left of light blue line: hunting frequent, cattle grazing, farming
  - Right of light blue line: hunting by special event only
- **Surrounding area is a mix of farmland and wooded areas**
- **Initial results; evaluation ongoing**

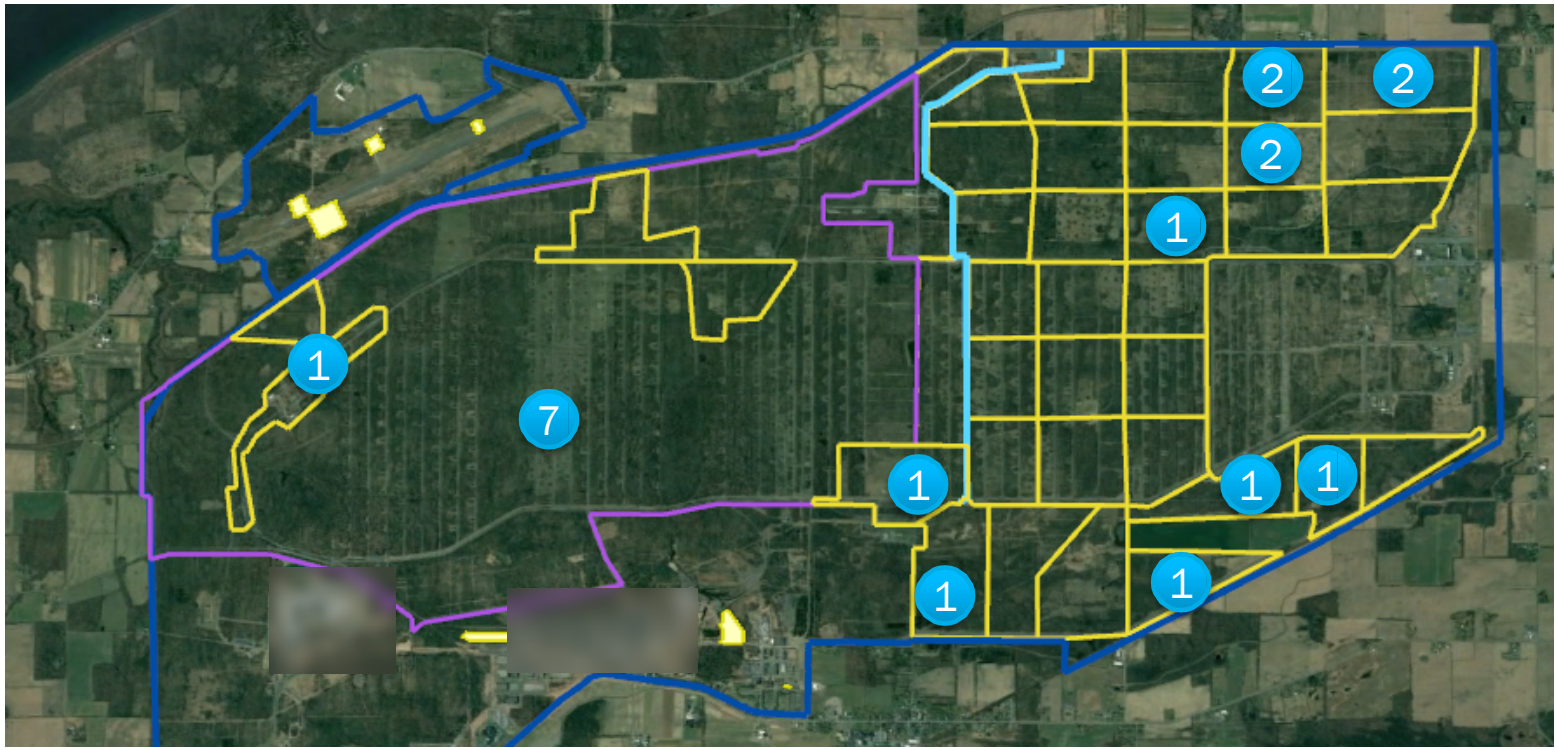
DEER TISSUE COLLECTION

- **Hunters brought harvested deer to collection sites with State biologist**
  - Excludes left side
- **Collected paired muscle and liver tissue samples**
- **Information collected from each deer**
  - Sex
  - Weight (not left side)
  - Age (not left side)
  - Hunting area
- **Samples analyzed via USEPA Draft Method 1633**



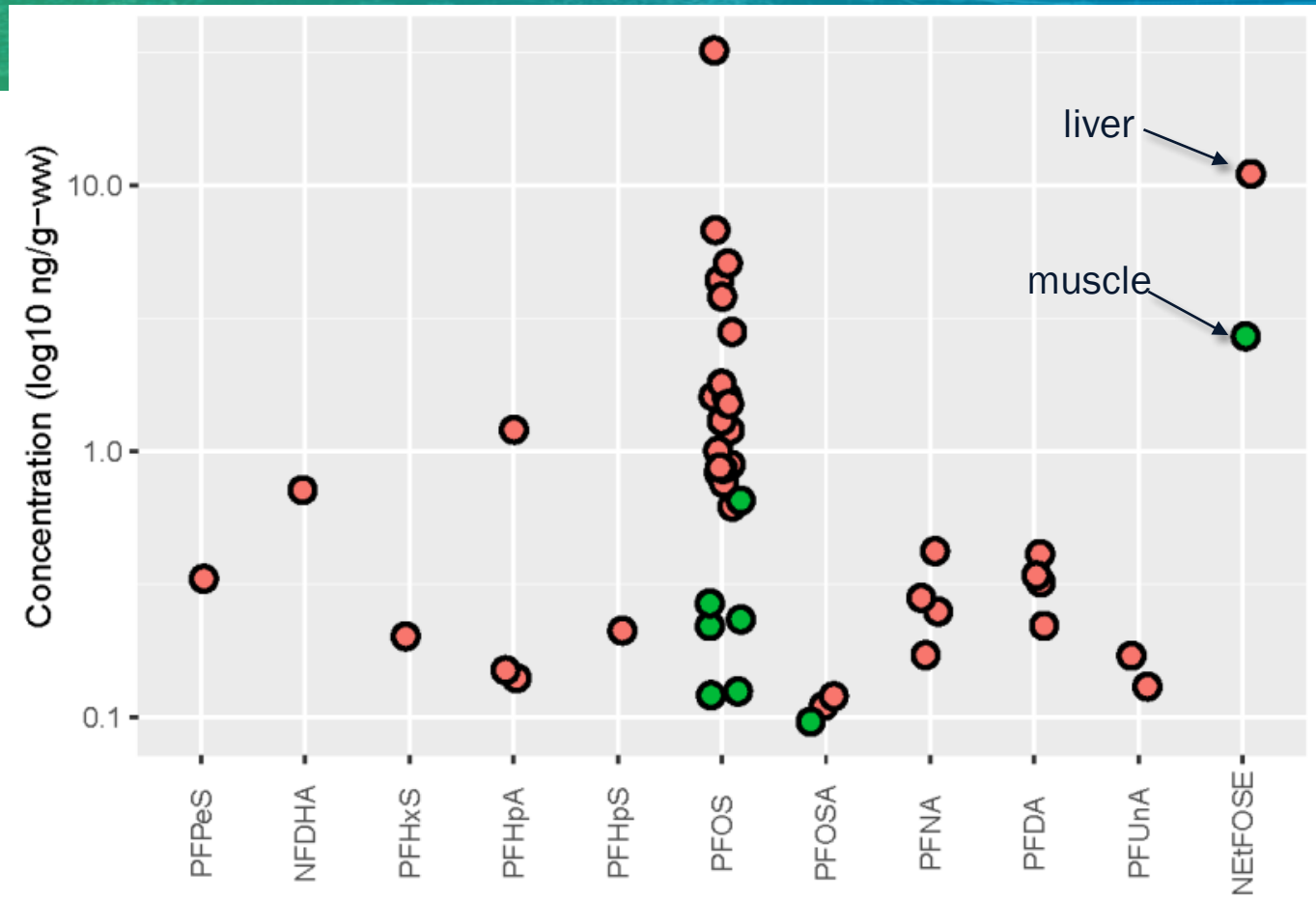
SAMPLES COLLECTED

- 20 deer sampled
  - Paired samples: muscle, liver
  - 3 duplicates of each type
- Samples collected from 11 different hunting areas
- Fences surrounds hunting area
  - 6 feet high, topped with barbed wire, but discontinuous
  - 10 feet on blue line
    - Barrier to deer movement



SAMPLES COLLECTED

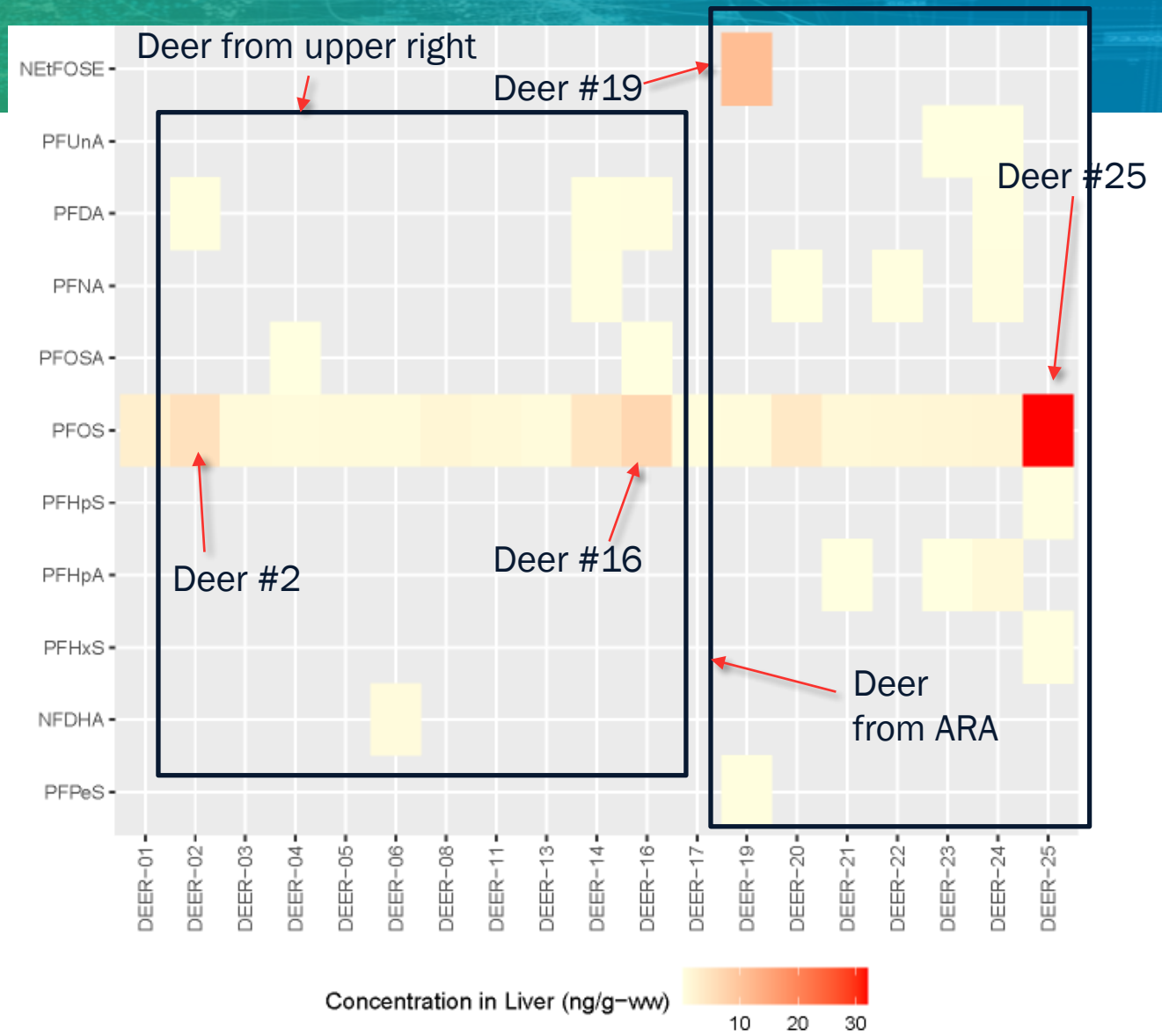
- All results ND in one deer
- PFAS detected in
  - 19/20 liver samples
  - 7/20 muscle samples
- PFOS most frequently detected
  - Muscle: 0.12-0.65 ng/g
  - Liver: 0.62-32 ng/g
- PFOS Liver:Muscle in 6 paired samples
  - Range: 2.7-49, Average: 18
- Several PFAS only detected in one animal: PFPeS, NFDHA, PFHxS, PFHpS, NEtFOSE



C#	5	5	6	7	7	8	8	9	10	11	12
Detects, liver	1	1	1	3	1	19	2	4	4	2	1
Detects, muscle	0	0	0	0	0	6	1	0	0	2	1

ANALYTICAL RESULTS

- Several different liver exposure “profiles”; e.g.,
- Deer #2 and #16
  - PFOS >5 ng/g in liver
  - Both from upper right on map
- Deer #19
  - only detections of PFPeS, NEtFOSE
  - From ARA
- Deer #25:
  - Highest PFOS (32 ng/g) in liver
  - Only deer with detected PFHxS, PFHpS
  - From ARA



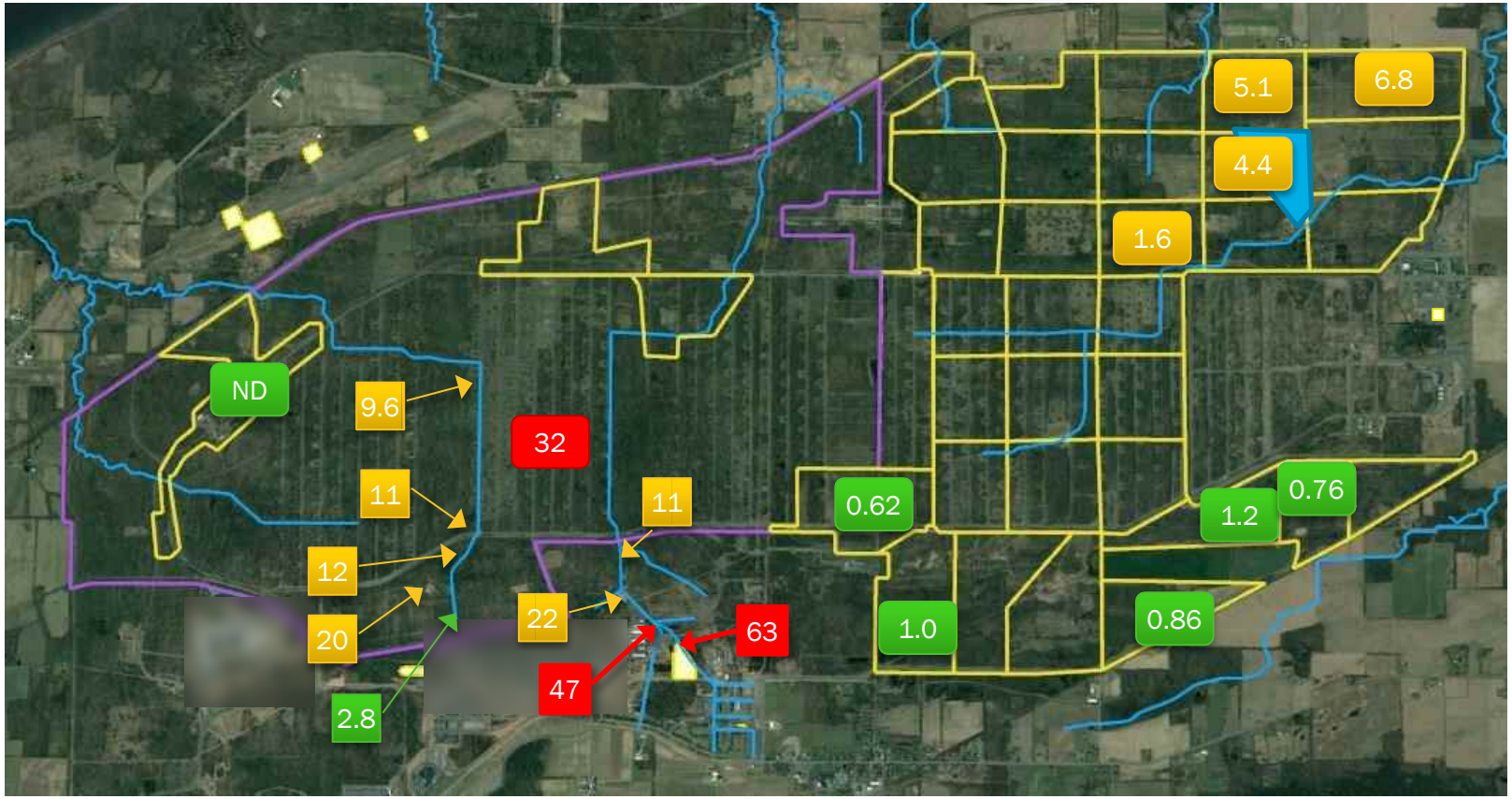
ANALYTICAL RESULTS

- Sufficient detected data for PFOS in liver to look for correlations*
  - Age: p = 0.5
  - Weight: p = 0.9
  - Age was correlated with weight: p = 0.003
- No soil data collected from same areas
- Hunting area with highest PFOS in liver, has high PFOS in surface water. Also, upper right.
- Area in upper right, is former OB/OD area (no soil samples)

Maximum Detected PFOS Concentrations

Liver (ng/g-ww) 1.0 Low to high 32

Water (ng/L) 2.8 Low to high 63



*spearman rank order correlation

ANALYTICAL RESULTS: COMPARISON

- Concentrations of PFOS detected in this study generally lower than elsewhere
- Similar to other studies, PFOS most frequently detected

Parameter	PFOS Muscle (ng/g-ww)	PFOS Liver (ng/g-ww)	#
Maine, Fairfield area, 2021	1.4 – 43.5	5.5 – 809	8
Michigan, Statewide, 2018	<0.25 – 548	<0.25 – 6,080	20
Michigan, Huron River, 2019	<0.25	<0.25 – 4.5	20
Michigan, Oscoda Area (Wurtsmith AFB), 2021	ND – 83	ND – 2,970	44
Wisconsin, Tyco Fire Center, 2020	ND – 2.7	3.8 - 92	20
This study, New York, 2023	<0.24 – 0.65	<0.25 – 32	20

HUMAN HEALTH EXPOSURES

- Estimated exposures and risks using modified USEPA equations
  - Modified to remove body weight – ingestion rate is weight normalized

$$ADD = \frac{(EPC)(IF_{adj})(EF)(CF)(FV)}{(AT)}$$

$$ADD = \frac{(EPC)(IR)(EF)(ED)(CF)(FV)}{(AT)}$$

$$IF_{adj} = (ED_{child})(IR_{child}) + (ED_{adult})(IR_{adult})$$

$$Risk = (ADD)(SF_o)$$

$$Hazard\,quotient = ADD/RfD_o$$

Abbreviation	Parameter	Abbreviation	Parameter
ADD	Average daily dose	FV	Fraction consumed from site
AT	Averaging time	IF	Ingestion rate, age adjusted
CF	Conversion factor	IR	Ingestion rate
EF	Exposure frequency	RfDo	Reference dose, oral
ED	Exposure duration	SFo	Slope factor, oral
EPC	Exposure point concentration		

HUMAN HEALTH EXPOSURES

- Assuming local residents are hunters
- Used standard USEPA residential exposure parameters

Parameter	Abbreviation	Value	Units
Exposure Frequency	EF	350	days/year
Exposure Duration - adult	ED_{adult}	20	years
Exposure Duration - child	ED_{child}	6	years
Averaging Time – carcinogens	AT_c	25,550	days
Averaging Time – noncarcinogens, child	AT_{nc} - child	2,190	days
Averaging Time – noncarcinogens, adult	AT_{nc} - adult	7,300	days
Body Weight - adult	BW_{adult}	80	kg
Body Weight - child	BW_{child}	15	kg

HUMAN HEALTH EXPOSURES

- Deer ingestion rate is not standard
  - USEPA 2018 Exposure Factors Handbook Table 11-1 has

Parameter	Abbreviation	Value (g/kg-day-ww)	WW to DW conversion (kg dw/kg ww)	Value (g/kg-day-dw)
Total meat ingestion rate, consumers only, adult	IR_{adult}	1.79	0.2938	0.529
Total meat ingestion rate, consumers only, child	IR_{child}	3.75	0.2938	1.09

  - Conversion factor from Table 11-42: 70.62% moisture content for “raw, lean only” beef
    - 1 - 0.7062 = 0.2938
- Assume hunters eat both muscle and liver
  - Assumed liver is 1/15 mass of muscle harvested
  - Resulting ingestion rates are:

Parameter	Abbreviation	Muscle (g/kg-day-ww)	Liver (g/kg-day-dw)
Ingestion rate, adult	IR_{adult}	0.494	0.035
Ingestion rate, child	IR_{child}	1.02	0.073

HUMAN HEALTH TOXICITY VALUES

- Used toxicity values from May 2024 USEPA RSL tables

CAS Number	Analyte		RfD_o (mg/kg-day)	SF_o ((mg/kg-day)$^{-1}$)	GIABS (unitless)
2706-91-4	Perfluoropentanesulfonic acid	PFPeS	--	--	--
151772-58-6	Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	--	--	--
355-46-4	Perfluorohexanesulfonic acid	PFHxS	2.0E-05		1
375-85-9	Perfluoroheptanoic acid	PFHpA	--	--	--
375-92-8	Perfluoroheptanesulfonate	PFHpS	--	--	--
1763-23-1	Perfluorooctanesulfonic acid	PFOS	1.0E-07	3.95E+01	1
754-91-6	Perfluorooctane sulfonamide	PFOSA	--	--	--
375-95-1	Perfluoro-n-nonanoic acid	PFNA	3.0E-06		1
335-76-2	Perfluorodecanoic acid	PFDA	--	--	--
2058-94-8	Perfluoroundecanoic acid	PFUnA	3.0E-04		1
1691-99-2	N-ethylperfluoro-1-octanesulfonamido ethanol	NEtFOSE	--	--	--

HUMAN HEALTH RISKS

- **Assuming: 33% of meat consumed comes from sample area**

EPC = Maximum Detected Concentration

	EPC		Cancer Risk	Noncancer Hazard Quotient	
	(mg/kg-ww)	(mg/kg-dw)	(unitless)	Child (unitless)	Adult (unitless)
Muscle					
PFOS	6.5E-04	2.2E-03	6.3E-06	7.2	3.5
Liver					
PFHxS	2.0E-04	6.8E-04	--	7.9E-04	3.8E-04
PFOS	3.2E-02	1.1E-01	2.22E-05	25	12
PFNA	4.2E-04	1.4E-03	--	0.011	0.0053
PFUnA	1.7E-04	5.8E-04	--	4.5E-05	2.2E-05
		Total	3E-05	32	16

EPC = UCL95 Concentration

	EPC		Cancer Risk	Noncancer Hazard Quotient	
	(mg/kg-ww)	(mg/kg-dw)	(unitless)	Child (unitless)	Adult (unitless)
Muscle					
PFOS	2.5E-04	8.5E-04	2.4E-06	2.8	1.3
Liver					
PFHxS	2.0E-04	6.8E-04	--	7.9E-04	3.8E-04
PFOS	6.2E-03	2.1E-02	4.29E-06	4.9	2.3
PFNA	3.7E-04	1.3E-03	--	0.010	0.0047
PFUnA	1.7E-04	5.8E-04	--	4.5E-05	2.2E-05
		Total	7E-06	8	4

HUMAN HEALTH RISKS

- **Assuming: All meat consumed comes from sample area**

EPC = Maximum Detected Concentration

	EPC		Cancer Risk	Noncancer Hazard Quotient	
	(mg/kg-ww)	(mg/kg-dw)	(unitless)	Child (unitless)	Adult (unitless)
Muscle					
PFOS	6.5E-04	2.2E-03	1.9E-05	22	10
Liver					
PFHxS	2.0E-04	6.8E-04	--	2.4E-03	1.2E-03
PFOS	3.2E-02	1.1E-01	6.7E-05	76	37
PFNA	4.2E-04	1.4E-03	--	0.033	0.016
PFUnA	1.7E-04	5.8E-04	--	1.3E-04	6.5E-05
		Total	9E-05	98	47

EPC = UCL95 Concentration

	EPC		Cancer Risk	Noncancer Hazard Quotient	
	(mg/kg-ww)	(mg/kg-dw)	(unitless)	Child (unitless)	Adult (unitless)
Muscle					
PFOS	2.5E-04	8.5E-04	7.4E-06	8.3	4.0
Liver					
PFHxS	2.0E-04	6.8E-04	--	0.0024	0.0012
PFOS	6.2E-03	2.1E-02	1.3E-05	15	7.1
PFNA	3.7E-04	1.3E-03	--	0.029	0.014
PFUnA	1.7E-04	5.8E-04	--	1.3E-04	6.5E-05
		Total	2E-05	23	11

CONCLUSIONS

- **Additional evaluation ongoing**
- **PFOS present in deer muscle and liver near AFFF sites**
  - Concentrations less than observed at other PFAS sites
- **Bioaccumulation not related to age or weight**
- **Deer potentially exposed via surface water ingestion**
- **Consumption of deer meat results in elevated risks**
  - Especially liver

QUESTIONS, COMMENTS, DISCUSSION?

?

THANK YOU!

APPENDIX: TREATMENT OF DUPLICATES

- **Only one result was used for parent sample and FD pairs.**
- **Result used was chosen as follows:**
  - If an analyte was detected in both parent sample and FD, the maximum detection was used.
  - If an analyte was detected in only one sample, the detection was used.
  - If an analyte was not detected in either sample, the sample with the lower limit of detection was used.

APPENDIX: HUMAN HEALTH RISKS

- Assuming: 33% meat consumed comes from sample area
- EPC = Maximum Detected Concentration

							Cancer	Noncancer	Noncancer	Cancer	NoncancerHazard Quotient	
		CAS	SFo	RfDo	EPC	EPC	ADD/Ingestion$_{age\text{-}adj}$	ADD/Ingestion - Child	ADD/Ingestion - Adult	Risk	Child	Adult
		Number	$(mg/kg\text{-}day)^{-1}$	(mg/kg-day)	(mg/kg-ww)	(mg/kg-dw)	(mg/kg-day)	(mg/kg-day)	(mg/kg-day)	(unitless)	(unitless)	(unitless)
Muscle												
Perfluorooctanesulfonic acid	PFOS	1763-23-1	4.0E+01	1.0E-07	6.5E-04	2.2E-03	1.6E-07	7.2E-07	3.5E-07	6.3E-06	7.2	3.5
Liver												
Perfluorohexanesulfonic acid	PFHxS	355-46-4		2.0E-05	2.0E-04	6.8E-04	3.5E-09	1.57E-08	7.59E-09	--	7.9E-04	3.8E-04
Perfluorooctanesulfonic acid	PFOS	1763-23-1	4.0E+01	1.0E-07	3.2E-02	1.1E-01	5.63E-07	2.51E-06	1.22E-06	2.2E-05	25	12
Perfluoro-n-nonanoic acid	PFNA	375-95-1		3.0E-06	4.2E-04	1.4E-03	7.4E-09	3.30E-08	1.59E-08	--	0.011	0.0053
Perfluoroundecanoic acid	PFUnA	2058-94-8		3.0E-04	1.7E-04	5.8E-04	3.0E-09	1.34E-08	6.46E-09	--	4.5E-05	2.2E-05
									Total	3E-05	32	16

APPENDIX: HUMAN HEALTH RISKS

- Assuming: 33% meat consumed comes from sample area
- EPC = UCL95 Concentration

							Cancer	Noncancer	Noncancer	Cancer	NoncancerHazard Quotient	
		CAS	SFo	RfDo	EPC	EPC	$ADD/Ingestion_{age\text{-}adj}$	ADD/Ingestion - Child	ADD/Ingestion - Adult	Risk	Child	Adult
		Number	$(mg/kg\text{-}day)^{-1}$	(mg/kg-day)	(mg/kg-ww)	(mg/kg-dw)	(mg/kg-day)	(mg/kg-day)	(mg/kg-day)	(unitless)	(unitless)	(unitless)
Muscle												
Perfluorooctanesulfonic acid	PFOS	1763-23-1	4.0E+01	1.0E-07	2.5E-04	8.5E-04	6.2E-08	2.8E-07	1.3E-07	2.4E-06	2.8	1.3
Liver												
Perfluorohexanesulfonic acid	PFHxS	355-46-4		2.0E-05	2.0E-04	6.8E-04	3.5E-09	1.6E-08	7.59E-09	--	7.9E-04	3.8E-04
Perfluorooctanesulfonic acid	PFOS	1763-23-1	4.0E+01	1.0E-07	6.2E-03	2.1E-02	1.09E-07	4.9E-07	2.35E-07	4.29E-06	4.9	2.3
Perfluoro-n-nonanoic acid	PFNA	375-95-1		3.0E-06	3.7E-04	1.3E-03	6.5E-09	2.91E-08	1.40E-08	--	0.010	0.0047
Perfluoroundecanoic acid	PFUnA	2058-94-8		3.0E-04	1.7E-04	5.8E-04	3.0E-09	1.34E-08	6.46E-09	--	4.5E-05	2.2E-05
									Total	7E-06	8	4

APPENDIX: HUMAN HEALTH RISKS

- Assuming: All meat consumed comes from sample area
- EPC = Maximum Detected Concentration

							Cancer	Noncancer	Noncancer	Cancer	NoncancerHazard Quotient	
		CAS	SFo	RfDo	EPC	EPC	$ADD/Ingestion_{age\text{-}adj}$	ADD/Ingestion - Child	ADD/Ingestion - Adult	Risk	Child	Adult
		Number	$(mg/kg\text{-}day)^{-1}$	(mg/kg-day)	(mg/kg-ww)	(mg/kg-dw)	(mg/kg-day)	(mg/kg-day)	(mg/kg-day)	(unitless)	(unitless)	(unitless)
Muscle												
Perfluorooctanesulfonic acid	PFOS	1763-23-1	4.0E+01	1.0E-07	6.5E-04	2.2E-03	4.8E-07	2.2E-06	1.0E-06	1.9E-05	22	10
Liver												
Perfluorohexanesulfonic acid	PFHxS	355-46-4		2.0E-05	2.0E-04	6.8E-04	1.1E-08	4.76E-08	2.30E-08	--	2.4E-03	1.2E-03
Perfluorooctanesulfonic acid	PFOS	1763-23-1	4.0E+01	1.0E-07	3.2E-02	1.1E-01	1.71E-06	7.62E-06	3.68E-06	6.7E-05	76	37
Perfluoro-n-nonanoic acid	PFNA	375-95-1		3.0E-06	4.2E-04	1.4E-03	2.2E-08	1.00E-07	4.83E-08	--	0.033	0.016
Perfluoroundecanoic acid	PFUnA	2058-94-8		3.0E-04	1.7E-04	5.8E-04	9.1E-09	4.05E-08	1.96E-08	--	1.3E-04	6.5E-05
									Total	9E-05	98	47

APPENDIX: HUMAN HEALTH RISKS

- Assuming: All meat consumed comes from sample area
- EPC = UCL95 Concentration

							Cancer	Noncancer	Noncancer	Cancer	NoncancerHazard Quotient	
		CAS	SFo	RfDo	EPC	EPC	$ADD/Ingestion_{age\text{-}adj}$	ADD/Ingestion - Child	ADD/Ingestion - Adult	Risk	Child	Adult
		Number	$(mg/kg\text{-}day)^{-1}$	(mg/kg-day)	(mg/kg-ww)	(mg/kg-dw)	(mg/kg-day)	(mg/kg-day)	(mg/kg-day)	(unitless)	(unitless)	(unitless)
Muscle												
Perfluorooctanesulfonic acid	PFOS	1763-23-1	4.0E+01	1.0E-07	2.5E-04	8.5E-04	1.9E-07	8.3E-07	4.0E-07	7.4E-06	8.3	4.0
Liver												
Perfluorohexanesulfonic acid	PFHxS	355-46-4		2.0E-05	2.0E-04	6.8E-04	1.1E-08	4.8E-08	2.30E-08	--	0.0024	0.0012
Perfluorooctanesulfonic acid	PFOS	1763-23-1	4.0E+01	1.0E-07	6.2E-03	2.1E-02	3.29E-07	1.5E-06	7.11E-07	1.3E-05	15	7.1
Perfluoro-n-nonanoic acid	PFNA	375-95-1		3.0E-06	3.7E-04	1.3E-03	2.0E-08	8.81E-08	4.26E-08	--	0.029	0.014
Perfluoroundecanoic acid	PFUnA	2058-94-8		3.0E-04	1.7E-04	5.8E-04	9.1E-09	4.05E-08	1.96E-08	--	1.3E-04	6.5E-05
									Total	2E-05	23	11